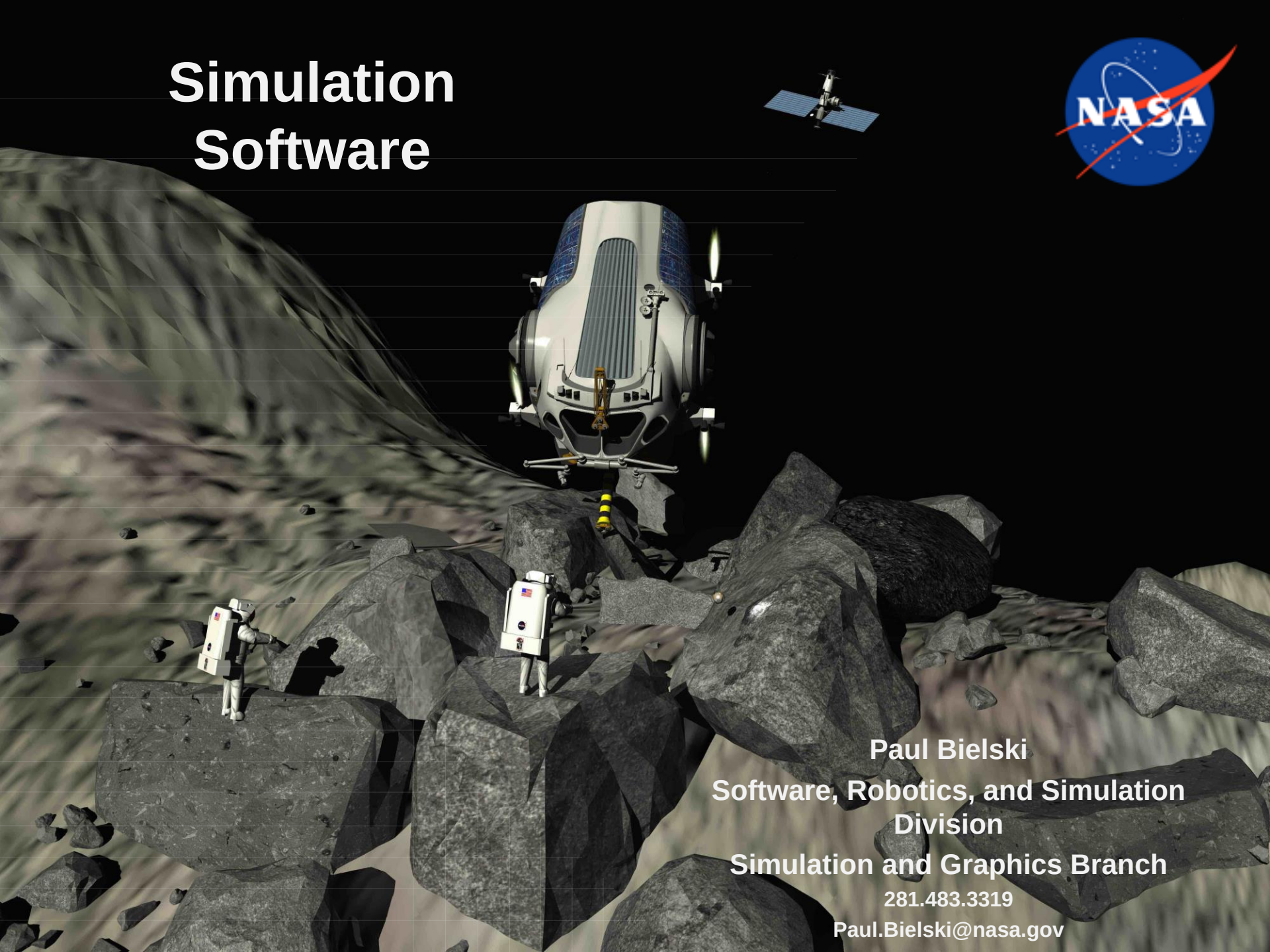
Simulation Software



Paul Bielski

Software, Robotics, and Simulation Division

Simulation and Graphics Branch

281.483.3319

Paul.Bielski@nasa.gov

Simulation Purpose

- **Evaluate the coupled effects of the environment, the vehicle configuration, and crew and ground activities as vehicles evolve throughout their life cycle**
- **Provide insight to project systems engineers and subsystem teams on the integrated effects of design selections**
- **Support testing of hardware and software in environments and conditions that are expensive or impossible to recreate on the ground**
- **Train operators on vehicle usage and provide insight into the effects of procedural inputs on the vehicle during operations**
- **Generally, early simulation allows insight into emergent vehicle behavior during the development phase rather than during integration, test, or operations**

Simulator Types

- **Analysis**
  - Single or multiple subsystem simulations that provide insight into vehicle design or operation, running on an engineer's desktop
  - Robotics, GN&C, Mechanisms, Power, Thermal, Life Support
- **Hardware-in-the-loop Systems**
  - Single or multiple subsystem simulation supplying a realistic environment to one or more hardware elements for analysis, testing, software development, or software verification purposes
  - Robotics, Avionics, GN&C
- **Human-in-the-loop Systems**
  - Full team, single system, or scenario training in dedicated facilities with representations of crew and flight controller interfaces used for training and procedure verification
  - Robotics, Avionics, GN&C, Mechanisms, Power, Thermal, Life Support

- **Many simulations cross these boundaries**
  - Begin life for analysis, and end up being used for hardware- or human-in-the-loop activities
  - A given simulation may be used throughout a program life cycle

Analysis Simulations

- **Mobile Servicing System (MSS) sim - ISS robotics**

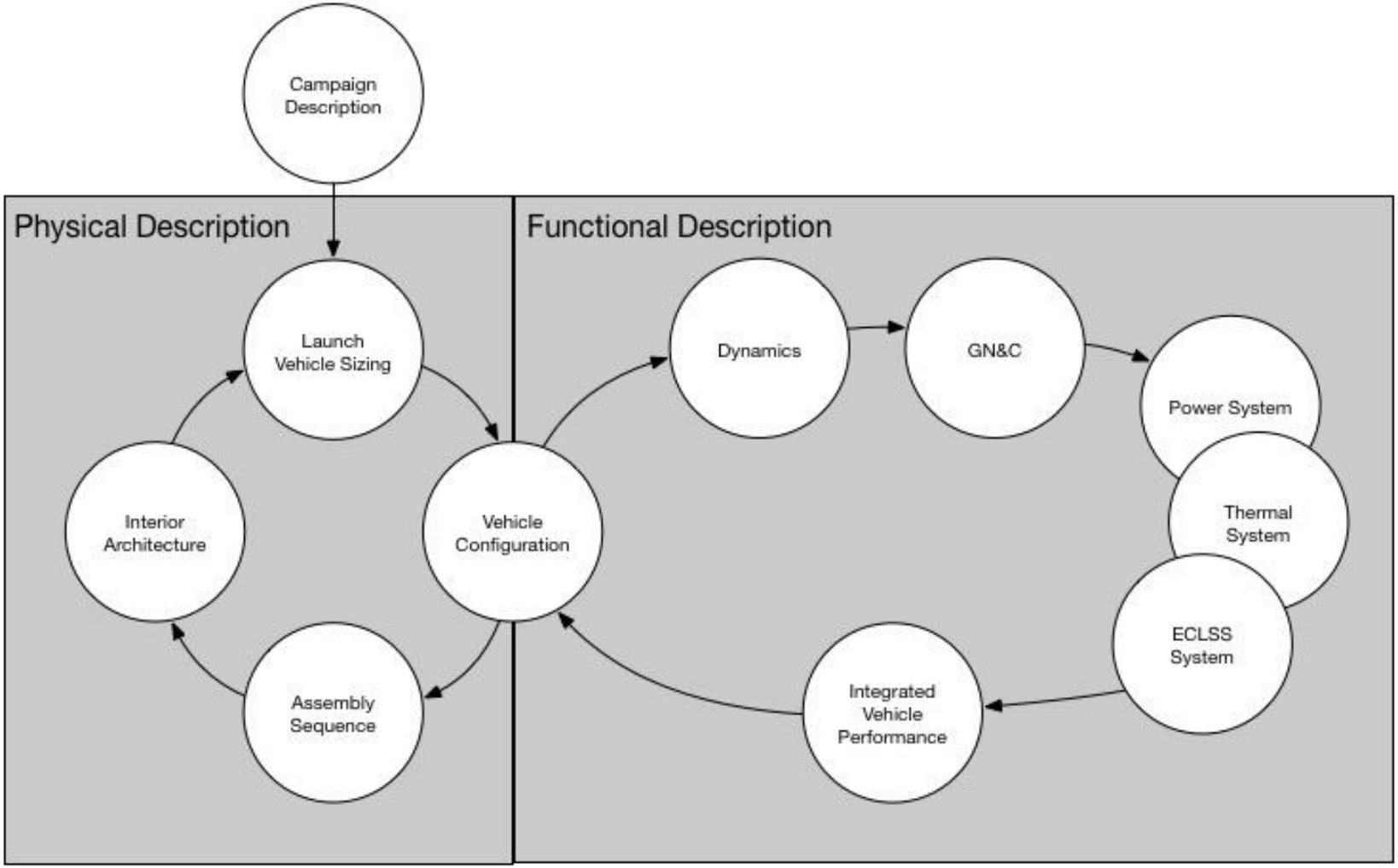
Hardware-in-the-Loop Simulation

- **Six Degree of Freedom Dynamic Test System (SDTS) – Stewart platform used to validate docking and berthing mechanisms**

Human-in-the-Loop Simulation

- **Systems Engineering Simulator (SES) – Real-time, crew-in-the-loop simulation of the dynamic flight phases of Shuttle, ISS, Orion, and future vehicles**

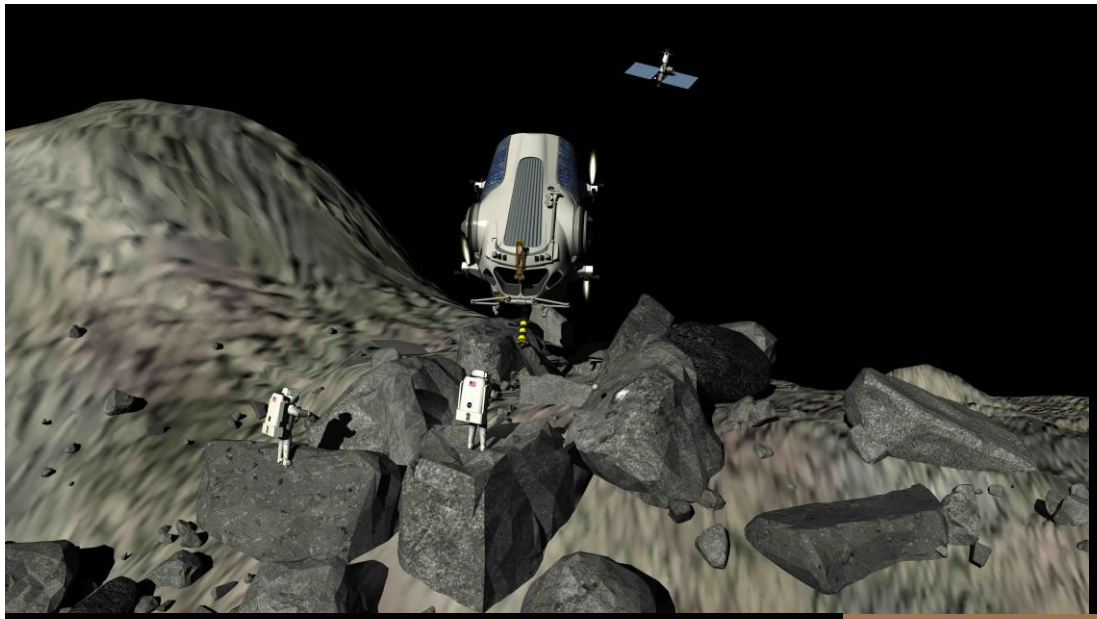
Iterative Development Approach

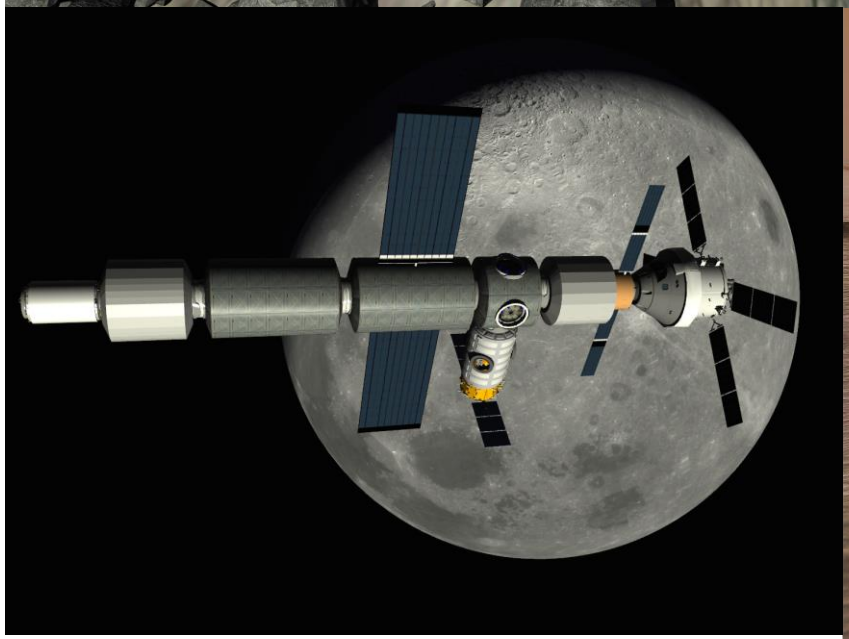


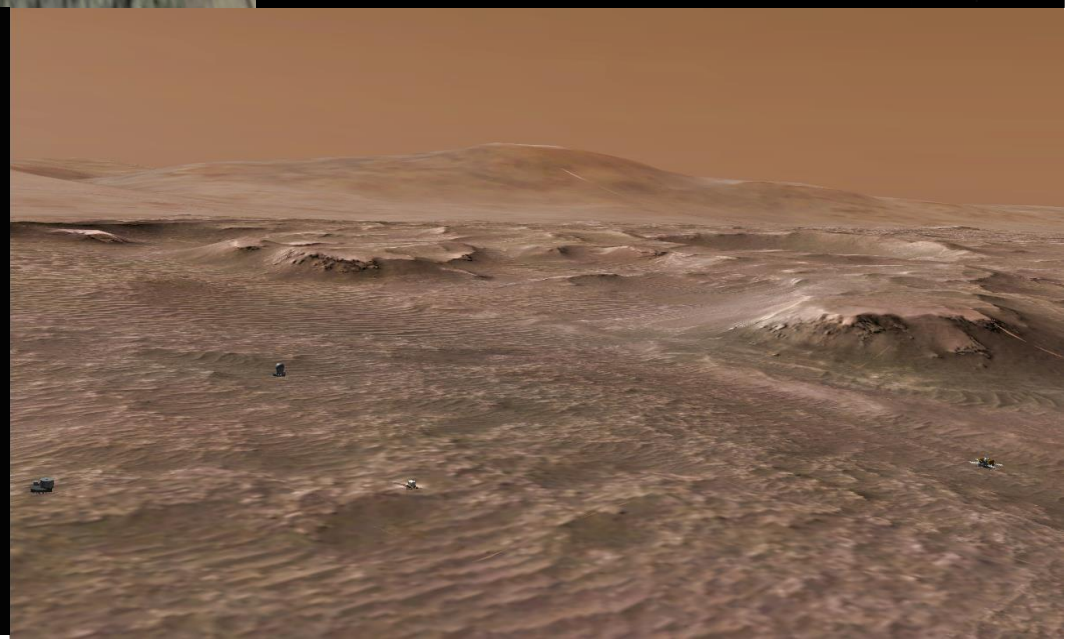
Integrated Vehicle Simulation Tools

- **Trick simulation environment provides model execution ordering, input processing, state integration, data recording, and post-processing capabilities**
- **JSC Engineering Orbital Dynamics (JEOD) provides environment models and 6-DOF dynamics**
- **General Use Nodal Network Solver (GUNNS) provides physics-based models of power, fluidic, and thermal systems**
- **Multibody Dynamics (MBDyn) provides kinematic and dynamic modeling of complex mechanisms including robots**
- **Pong and MechDyn provide modeling of complex contact surfaces, including terrain and mechanisms**
- **TrickHLA provides IEEE 1516 High Level Architecture (HLA) interface mechanism for all Trick simulations**
- **EDGE provides realtime graphics rendering capabilities**

Environment Modeling

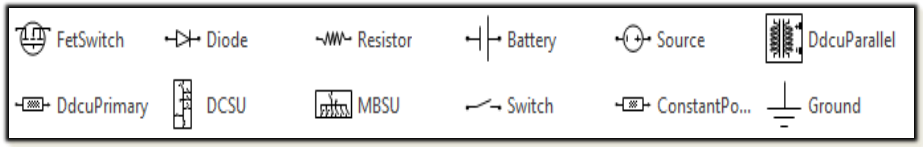


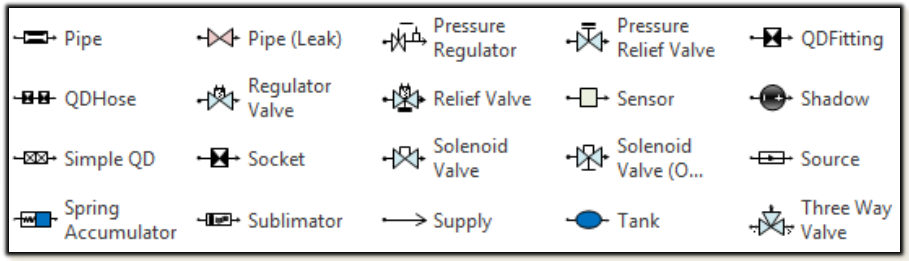


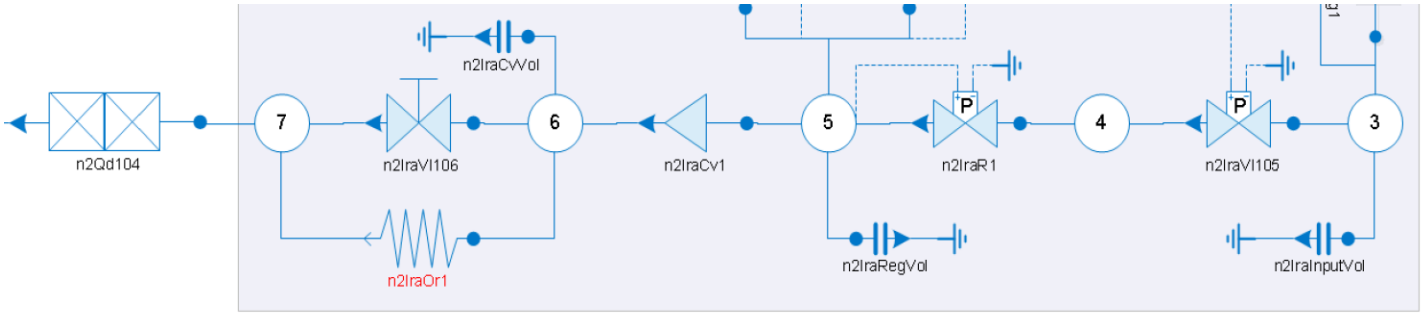


Vehicle Subsystem Modeling

- **GUNNS provides a common design and code generation development approach to three “aspects”**
  - Fluidic (plumbing, life support systems, thermal control)
  - Electrical (generation, distribution, loads)
  - Thermal (structure temperatures, solar heating, albedo)
- **Data-driven component models are developed once and reused across modeled subsystem designs**







Crew Inputs

Simulation throughout Life Cycle

- **Producing simulations early in the development phase allows leverage of the investment throughout the life cycle**
  - The system design can be influenced by the results of studies that leverage the simulation capability
  - Model fidelity can be improved as knowledge of the vehicle design improves, providing appropriate detail for each study
  - Simulation can be incorporated into flight software development and testing processes
  - Simulation can be incorporated into testing environments, supporting eventual substitution of sensor and effector models with hardware
  - During operations, simulation can be used for operator training and procedure check-out